

Chapter 2 Control Surveying Applications

2-1. General

Control surveys are used to support project control densification, structural deformation studies, photogrammetry, dynamic positioning and navigation for hydrographic survey vessels and dredges, hydraulic study/survey location, river/floodplain cross-section location, core drilling location, environmental studies, levee overbank surveys, levee profiling, levee grading and revetment placement, disposal area construction, grade control, support for real estate surveys and regulatory enforcement actions.

2-2. Project Control Densification

a. Conventional surveying. Conventional control surveys can be used to economically and accurately establish or densify project control in a timely fashion. Quality control statistics and redundant measurements in networks established by these methods help to ensure reliable results. However, conventional survey methods do have the requirement for intervisibility between adjacent stations.

b. GPS surveying. GPS survey techniques can often be used to establish or densify project control more efficiently than conventional control surveying techniques. Quality control statistics and redundant measurements in GPS networks help to ensure reliable results. Field operations to perform a GPS survey are relatively easy and can generally be performed by one person per receiver, with two or more receivers required to transfer control. GPS does not require intervisibility between adjacent stations. However, GPS must have visibility of at least four satellites (for position determination) during surveying. This requirement may make GPS inappropriate in areas of dense vegetation. For GPS control survey techniques refer to EM 1110-1-1003.

2-3. Geodetic Control Densification

Conventional control and GPS surveying methods can be used for wide-area high-order geodetic control densification. First-, Second- or Third-order work can be achieved using conventional or GPS surveying techniques.

2-4. Vertical Control Densification

Orthometric heights (from benchmarks located in the project area) and conventional leveling methods are used to determine elevations (orthometric heights) for vertical control densification. The setup and operation for conventional control surveying for vertical control densification offers economies of scale in the same manner as that offered by the setup for project control densification: smaller projects require less setups, while larger projects require more. The procedures for using GPS for vertical control densification are covered in further detail in EM 1110-1-1003.

2-5. Structural Deformation Studies

a. Conventional control surveying can be used to monitor the motion of points on a structure relative to stable monuments. This can be done with an array of calibrated reflectors positioned at selected points on the structure, an Electronic Distance Measuring instrument (EDM) alternated on various remote stable monuments, and trilateration techniques. These precise techniques can provide a direct measure of the displacement of a structure as a function of time. If procedures are strictly adhered to, it is possible to achieve $\pm 0.5 \text{ mm} + 4 \text{ ppm}$ (4 mm/km) for baseline using conventional surveying. Personnel requirements generally are two personnel once the initial test network of reference and object points are set up: one person to monitor the EDM, another to aid in reflector placement.

b. GPS can be used to monitor the motion of points on a structure relative to stable monuments. With GPS, an array of antennae are positioned at selected points on the structure and on remote stable monuments as opposed to using reflectors and EDMs as previously described. The baselines between the antennae are formulated to monitor differential movement. The relative precision of the measurements is on the order of $\pm 5 \text{ mm}$ over distances averaging between 5 and 10 km. Formulations can be determined continuously 24 hours a day, depending on GPS constellation availability. Once a deformation monitoring system has been set up using GPS, it can be operated unattended and is relatively easy to maintain. More specific guidance on the use of GPS for deformation monitoring is included in EM 1110-1-1003.

c. Methods for deformation determination, including the direct measurement of deformation parameters (e.g., tilt, strain, stress, etc.), the real-time processing of continuously recorded deformation data, the structural finite element method, and the integrated analysis of deformation measurements, are not covered in this manual. For further information on these techniques, the user should consult any of the references listed in Appendix A relative to the particular subject.

2-6. Photogrammetry

Conventional control and GPS surveying can be used in the support of photogrammetric applications. More specific guidance on the use of control surveying in support of photogrammetry is included in EM 1110-1-1000.

2-7. Dynamic Positioning and Navigation

a. Conventional control surveying can be used to establish control for the dynamic positioning and navigation of construction and surveying platforms used for design, construction, and environmental regulatory efforts. These efforts include dredge control systems, site investigation studies/surveys, horizontal and vertical construction placement, hydraulic studies, or any other activity requiring two- or three-dimensional control. Second- or Third-Order leveling is required for these efforts.

b. GPS can reduce the time and effort required to install control for dynamic positioning and navigation. In addition to this capability, properly equipped GPS equipment can provide dynamic, real-time GPS code and carrier phase positioning of construction and surveying platforms. GPS code phase differential techniques can provide real-time meter-level horizontal positioning and navigation, while GPS carrier phase differential techniques can provide real-time centimeter-level three-dimensional positioning and navigation. These GPS methods can be used for any type of construction or survey platform (e.g., dredges, graders, survey vessels, etc.). More specific guidance on the use of GPS for dynamic positioning and navigation is included in EM 1110-1-1003.

2-8. GIS Integration

A Geographic Information System (GIS) can be used to correlate and store diverse information on natural or man-made characteristics of geographic positions. To effectively establish and use a GIS, it must be based on accurate geographic coordinates. A GIS with an accurate foundation of geographic coordinates enables the user to readily exchange information between databases. Conventional control surveying and GPS surveying can be used to establish the geographic coordinates used as the foundation for a GIS.